

in latest modes from SSM. Further research is necessary to compare the contribution of both, SSM and GPs to identify the variations in hip morphology that precede hip pathology.

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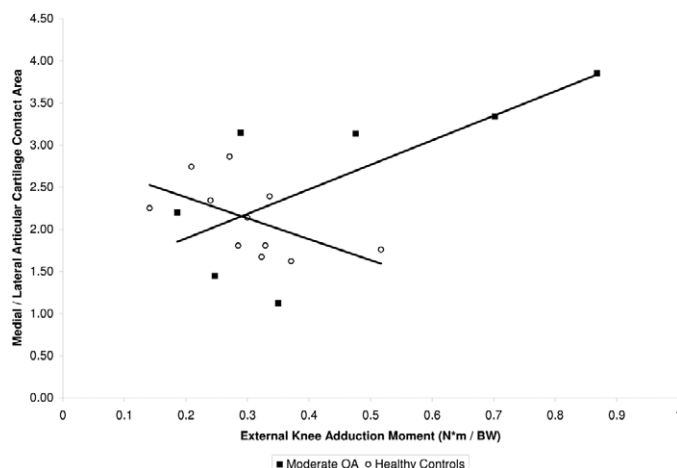
##### THE RELATIONSHIP BETWEEN THE KNEE ADDUCTION MOMENT AND DISTRIBUTION OF CARTILAGE CONTACT AREA IN THE TIBIOFEMORAL JOINT IN HEALTHY, OLDER ADULTS AND SUBJECTS WITH MODERATE KNEE OSTEOARTHRITIS

C. Henderson, A. Kubinski, J. Higginson  
Univ. of Delaware, Newark, DE

**Purpose:** The purpose of this study was to investigate the relationship between the peak external knee adduction moment during gait and the ratio of medial to lateral articular cartilage contact area in the tibiofemoral joint during full extension and weightbearing. It is hypothesized that the ratio of articular cartilage contact area may be representative of frontal plane joint alignment. Previous knee OA investigations have placed a high emphasis on frontal plane knee alignment. An increased medial to lateral articular cartilage contact area ratio would suggest a varus knee mal-alignment and an increased external knee adduction moment. It is hypothesized that healthy controls will demonstrate this relationship, while subjects with moderate knee OA will not.

**Methods:** Magnetic resonance imaging (MRI), gait data, and anterior-posterior radiographs were collected on 18 subjects. Subjects were required to be 30–85 years in age, have a body mass index less than 35, and able to walk on a treadmill at a self-selected speed for five minutes. Kellgren-Lawrence (KL) grading was determined by a radiologist through use of anterior-posterior radiographs of both knees. KL grading in the medial compartment of the more severe knee distinguished moderate OA subjects (KL = 2–3) from healthy controls (KL = 0–1) and subjects with laterally dominant OA or OA in any of the other lower limb joints were excluded. T1 fast spin echo sequence MRI data were collected in an open scanner with the scanning table almost vertical (85°) while the subject stood at full knee extension. Scan parameters consisted of 30 sagittal slices with a 3.0 mm slice thickness, a 3.3 mm interval between slices, a field of view of 25 cm, echo time of 20 ms, a repetition time of 355 ms, a display matrix of 512×512, and a total scan time of approximately 6 minutes. Gait data were collected at the subject's self selected walking speed on an instrumented treadmill using an eight camera passive motion capture system and analyzed using commercially available software. The peak external knee adduction moment was identified and normalized to the subject's body mass. An analysis of covariance (ANCOVA) with alpha set at 0.05 was performed to compare the ratio of medial to lateral articular cartilage contact area to the normalized external knee adduction moment for the two groups. Student's t-tests were also performed to compare the group means.

**Results:** All subjects (7 moderate OA, 11 healthy controls) exhibited a medial contact area that was greater than the lateral compartment. No significant differences were found between the groups in peak external knee adduction moment ( $p=0.11$ ) or contact ratio ( $p=0.19$ ); however ANCOVA found a significant difference ( $p=0.019$ ) in the linear regression lines of the two groups.



**Conclusions:** Moderate OA subjects and healthy controls exhibited a significantly different relationship between medial to lateral articular cartilage contact area ratio and external knee adduction moment. Moderate OA subjects generally exhibited an increased peak external knee adduction moment with an increasing contact area ratio, while the healthy controls demonstrated a decreased contact area ratio with an increasing knee adduction moment. The increasing contact area ratio may suggest that the OA subjects are able to better distribute the loads incurred from the increased peak external knee adduction moment during gait and decrease stress in the medial compartment which in turn may decrease the rate of disease progression.

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##### INCREASED CAPSULAR RESTRICTION AND STIFFNESS IN A RAT KNEE FLEXION CONTRACTURE MODEL

Y. Onoda<sup>1</sup>, Y. Hagiwara<sup>2</sup>, E. Chimoto<sup>1</sup>, A. Ando<sup>1</sup>, H. Suda<sup>1</sup>, Y. Saijyo<sup>3</sup>, E. Itoi<sup>1</sup>

<sup>1</sup>Dept. of Orthopaedic Surgery, Tohoku Univ. Sch. of Med., Sendai, Japan;

<sup>2</sup>Takeda Gen. Hosp., Aizuwakamatsu, Japan; <sup>3</sup>Graduate Sch. of BioMed. Engineering, Tohoku Univ., Sendai, Japan

**Purpose:** A joint contracture is often seen in daily examinations, but its pathogenesis has been unsolved. Causes of joint contracture are classified into two types of components, arthrogenic (bone, cartilage, synovial membrane, capsule and ligaments) and myogenic ones (muscle, tendon, and fascia). Among the arthrogenic components, capsular stiffness might contribute more to joint contracture than the other ones. However, it is not known how the elasticity of the capsule is affected by joint immobilization. Acoustic microscopy for medicine and biology has been developed for more than twenty years at Tohoku University. Scanning acoustic microscopy (SAM) characterizes biological tissues by estimating the elastic parameters based on the sound speed, which strongly correlates with Young's elastic modulus.

The purpose of this study was to evaluate contribution of the capsule on limitation in range of motion and applied SAM to estimate elastic changes of the capsule after joint immobilization.

**Methods:** *Animals:* Adult male Sprague-Dawley rats' knees were immobilized at 150° of flexion by rigid internal fixation with a plastic plate and metal screws for various periods (1, 2, 4, 6, 8, and 16 weeks). Sham operated rats had holes drilled in the femur and tibia with screws, but the plate was not inserted. The immobilized animals and the sham operated animals made up the immobilized group and the control group, respectively.

*Measurement of a joint angle:* A special apparatus for taking lateral x-rays of the knees were made and the angle between the femur and tibia after total extra-articular myotomies were measured ( $n=8$ /each group). We set three torques (450, 900, 1350 g-cm). To know the influence of the posterior capsule, it was incised with a surgical knife after measuring the angle at the maximum torque (Figure 1). After the release, the joint angle was measured again with the maximum torque.

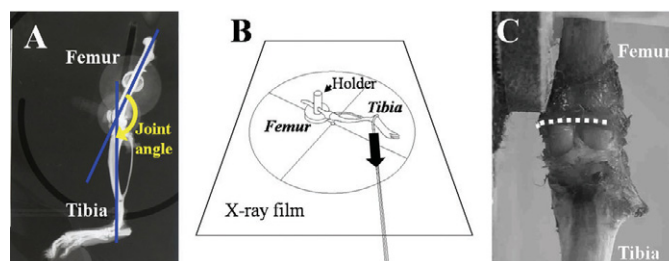


Figure 1

**Scanning acoustic microscopy (SAM):** A single pulsed ultrasound with 5 ns pulse width was emitted and received by the same transducer above the specimen. The reflections from the tissue surface and from interface between the tissue and the glass were received by the transducer. The sound speed was calculated by Fourier-transforming the waveform. SAM images with a gradation color scale were also produced for clear visualization of the sound speed. Normal light microscopic images corresponding to the stored acoustic images were captured.

**Results:** Limitation in extension progressed gradually over the experimental periods before the capsular release. After the release of the posterior

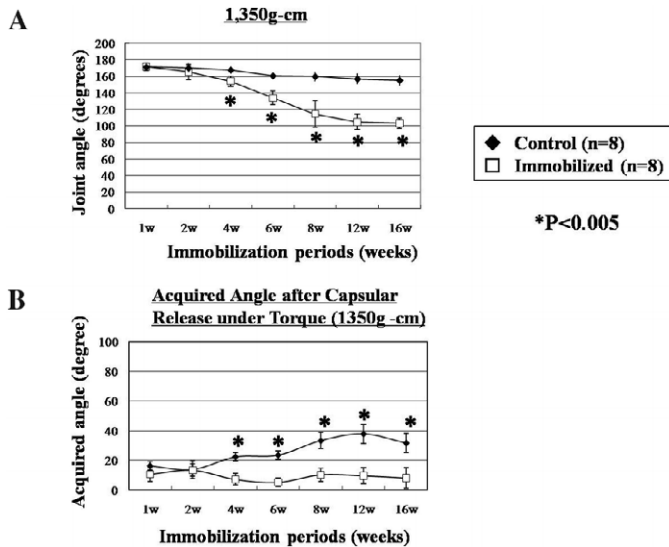


Figure 2

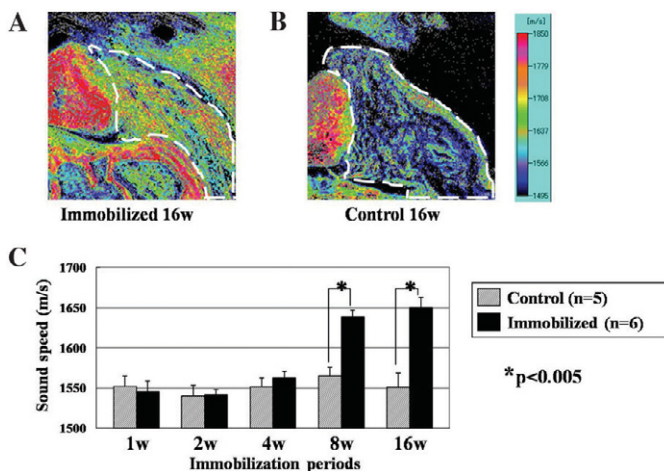


Figure 3

capsule, the acquired angle in the immobilized group was significantly greater than in the control group after 4 weeks and became plateau after 8 weeks (Figure 2). Sound speed of the posterior capsule detected by SAM was increased compared to the control group after 8 weeks of immobilization (Figure 3).

**Conclusions:** Arthrogenic joint contracture develops at the early stage of immobilization and progresses over time. Structural changes of the posterior capsule were one of the main causes of joint contracture.

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##### GROSS FEMORAL ROTATION MODELLED USING ACTIVE SHAPE MODELS

J.E. Anderson, R.M. Aspden, D.M. Reid, R.J. Barr, J.S. Gregory  
Univ. of Aberdeen, Aberdeen, United Kingdom

**Purpose:** Active shape models (ASM) can characterize and quantify the shape of the femur from radiographs or DXA scans. They have potential to identify people at increased risk of hip fracture in osteoporosis or requiring a total hip replacement in osteoarthritis (OA). However like any 2D image, these are sensitive to changes in 3D positioning. The aim of this study was to determine the effect of gross femoral rotation, an important aspect of patient positioning, on an ASM.

**Methods:** 10 cadaveric femurs from the anatomy department at the University of Aberdeen were scanned with a GE Lunar iDXA scanner (4 female, 6 male aged 31-75 years). Five femurs had signs of OA. Rice bags were used as a soft-tissue substitute. The femur was fixed in a jig. Initial scans were made at 0° anteversion (femoral neck parallel to the scanner table). Subsequent scans were made at rotations of 5° increments. All femurs

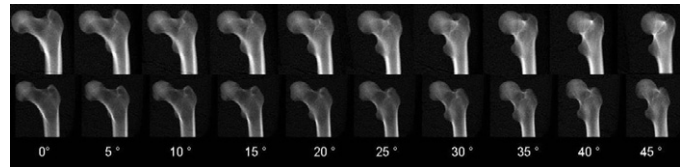


Figure 1

were scanned between 0° and 45°; half were also scanned to -15°. Typical images (0 - 45 degrees) are shown for 2 femurs (Figure 1)

A 29 point ASM was built and scores for the first 5 modes of variation recorded. Advanced Hip Analysis (AHA) using ENCORE software calculated Hip Axis Length (HAL), Neck-Shaft Angle (theta), Cross-sectional moment of inertia (CSMI), neck diameter (d3), distance from the head centre to; section of minimum CSMI along the neck axis (d1), intersection of neck and shaft (d2). Pearson correlation was used to calculate links between rotation and shape, ANOVA to separate the OA and non-OA groups.

**Results:** All AHA measures were significantly related to rotation ( $r=0.77-0.95$ ). HAL, d1 and d2 were negatively correlated whilst theta, CSMI and d3 were positively correlated. The first two ASM Modes were significantly correlated with rotation whilst Modes 3, 4 and 5 were independent.

Mode 1 score had a strong relationship with external rotation ( $r=0.97$ ) reflecting apparent changes in shape of the Lesser Trochanter, femoral neck and greater trochanter (Figure 2). Mode 2 was negatively correlated ( $r=-0.84$ ) and changes were again consistent with those expected with rotation. The OA group had significantly lower scores at each rotation than the non-OA group ( $P<0.05$ , Figure 3).

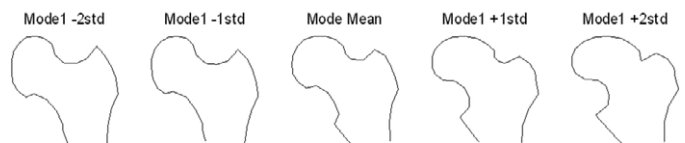


Figure 2

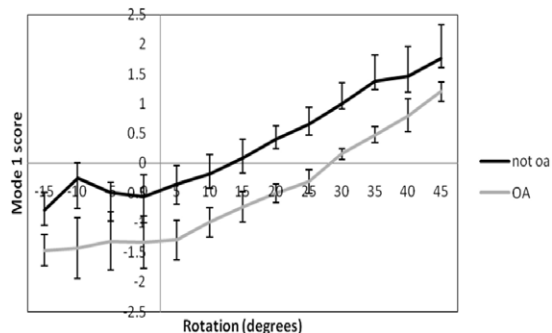


Figure 3

**Conclusions:** Our results demonstrate that some ASMs and all AHA geometrical measures are affected by femoral rotation, highlighting the need for care in patient positioning. However, only 2 of 5 ASM modes analysed were correlated with rotation, suggesting the possibility of separating rotational changes from an object's intrinsic shape. Further studies are required to investigate positional changes in more detail near the ideal DXA position and to explore aspects of positioning other than rotation, which may allow us to understand and minimize the effects of positioning on Active Shape Models in OA.

## Joint Tissue Anabolism and Catabolism

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##### AUGMENTED EXPRESSION OF SUPPRESSOR OF CYTOKINE SIGNALING (SOCS)-3 IN HUMAN PATHOLOGICAL CHONDROCYTES

S. Veenbergen, M.B. Bennink, G.T. Heldens, O.J. Arntz, H.M. van Beuningen, P.M. Kraan, W.B. van den Berg, F.A. van de Loo  
Radboud Univ. Nijmegen Med. Ctr., Nijmegen, Netherlands

**Purpose:** Osteoarthritis (OA), a degenerative joint disease, and Rheumatoid arthritis (RA), an inflammatory joint disease, are both characterized by